ON 28.

RAILROAD INJURIES

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Extremities of the Human Body

— WITH —

OBSERVATIONS ON THE SITE OF AMPUTATION

— AND —

Subsequent Treatment of the Stump.

COLLEGE OF SURGEONS ENGLAND

BY THEODORE R. VARICK, M. D.,

Medical Director of and Surgeon to St. Francis' Hospital, and Surgeon to Jersey City Charity Hospital, Jersey City, N. J.

Read before the American Medical Association, at its meeting in Washington, D. C., May 7th, 1884.

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The consideration of severe injuries of the extremities of the human body the result of rail road accidents, and indeed of all crushing blows inflicted by great momentum, is the topic which I have selected for discussion on this occasion.

I shall consider their proximate traumatisms, also their effect on the heart and great vessels.

For their effect on the nervous system, I refer you to the antagonistic works of Erichsen and Page.

Lastly, I shall offer a few observations on the subject of amputations and the after treatment of the stump, also the reports of a few cases bearing on the subject under discussion:

In the good old days of stage coaching, when travel as a rule was limited to nine inside and three outside, including the driver, and the speed of twelve miles an hour was considered a marvel, an occasional upset seldom resulted in more than a simple fracture, or when compound, scarcely ever comminuted, the offices of the surgeon were rarely called in for any other purpose than to apply splints, to reduce a dislocation, or to administer to sundry contusions.

In this progressive age, the increase of speed and multiplication of travelers are accompanied by increased frequency of accidents, and greater gravity of the traumatisms resulting from derailment, collisions, the coupling of cars, and the running down of unfortunate pedestrians who may not be able to get out of the way.

Owing to the great weight, and high rate of speed, injuries inflicted by trains in transit are of the most destructive character, producing comminution of bone, and laceration and pulpification of soft parts.

The traumatism is not confined to the immediate part struck, but extends far beyond.

The appearance of the integument is not always a criterion of the condition of the subjacent parts, as there may not be the slightest abrasion or mark of contusion thereon; yet the underlying muscular and vascular systems may be hopelessly destroyed.

It is a common observation that, concealed under the tegumentary condition above stated, we find rupture of the muscles, the bellies of which are full of ecchymotic patches, and at points, so pulpified as to be easily broken down by the fingers.

The inquiry naturally arises as to the "modus operandi" by which such results are produced.

It is difficult to imagine a force sufficiently powerful by direct impact, to produce such a disintegration of the subcutaneous parts, without leaving its impress on the surface, and we are compelled to look elsewhere for the cause.

It is a well recognized fact, that a muscle may be ruptured by its own contractile force especially when taken by surprise, or unprepared for the call made upon it, or when in an unnatural or awkward position when struck.

A case in point has recently come under my observation. I. L. C., aet 54, a strong heavy muscular man, while wheeling a bale of hay on a truck, on making a sudden effort for the purpose of ascending an incline, felt as he supposed, a smart blow on the calf of the left leg, followed by lameness. I saw the case six hours after the occurrence and found a subcutaneous depression about two inches in extent in its transverse diameter, in the external belly of the gastrocnemius, into which on pressure the finger readily sank.

There followed in a few hours extreme ecchymosis of the part.

At the present time (two months after the injury) the lameness has not entirely subsided, and the depression is well marked. So also the "lawn tennis" leg serves as an illustration of the pathological condition under consideration.

The effect of blows in producing muscular contraction is well illustrated by the tendon patellar reflex contraction of the quadriceps extensor.

A very firm amount of pressure on the ligamentum patellæ, or the tendon immediately above, gradually applied, produces scarcely any action on the part of the extensors of the leg; but let the same amount of force be applied in a sudden manner, and "up goes your foot."

The condition of ankle clonus is thus described: "If the foot is firmly flexed by pressure on the sole, and the tendo-achillis is tapped briskly, the foot at once undergoes flexion and extension in rapid succession for a considerable number of times. Gowers found the average number of contractions to be a little more than six in a second. By the aid of the myograph, Gowers has ascertained that the commencement of the ankle clonus occurs too soon after the blow upon the tendo-achillis, for the impression to travel up to the spinal cord and back to the muscles of the leg.

It is therefore concluded that unlike the knee phenomenon, the foot clonus is produced by the direct stimulation of the muscles both on the front and back of the leg through suddenly increased tension."*

In these instances although the mechanism is different, the effect on the muscular fibres is the same.

A blow upon a muscle held in extreme tension causes violent and repeated contraction, and as in the case where great momentum inflicts the blow, it is fair to assume that rupture of the contracting muscle or of its tendon to a greater or less extent may ensue.

In the tendon-reflex and ankle clonus, the joints are left free (except in the latter case when motion is only

* Reynold's System of Medicine, Vol. 1, page 987, Am. Ed.

restricted by manual pressure) to move as the muscles contract; but in the case of rail road injuries, one end of the limb is often held immovable between the rail and car wheel, while the other is fixed by the weight of the body, so that the force of muscular contraction is expended on the muscle itself.

This involuntary contraction in conjunction with the efforts of the victim to free himself, would produce some of the lesions which come under our observation.

Again, The liquids of the human body are confined within strong tegumentary and fascial coverings. Blows of many tons momentum rupture these envelopes in many places, pulpify and comminute the tissues beneath, and eject the liquids they contain with great force, and to great distances. These ejected liquids are sometimes thrown into other tissues, and the blood and lymph are driven back through the larger vessels with the same momentum as that of the blow struck.

The whole vascular system being a series of tubes, having a common centre at the heart, this organ, on its right side at the time of the blow, receives the impulse of venous blood, and should there exist any organic cardiac imperfection, a fatal paralysis, commonly known as shock, may result, paralysis from over-distension.

It is fair to assume that the rupture of the vessels of the part when struck a heavy blow, is in reality a fortunate circumstance so far as the life of the individual is concerned, as in this way a certain portion of the force is expended; for should the whole momentum of the projected current be thrown on the heart, instant death might result.

On the arterial side the blood flowing toward the part struck, is suddenly and forcibly arrested.

This sudden arrest of the circulation, is felt by the heart at its systole, producing heart strain, synchronous with the augmented propulsion thither on the venous side.

These forces together produce the results above described.

These results are in proportion to the size of the vessels involved in the injury, or, in other words, to the proximity to the heart.

After death from direct or primary shock, the heart is found gorged with blood, distended to its utmost capacity, together with general engorgement of the whole venous system.

In view of the tremendous power of the impinging force, is not this a reasonable, or at least a plausible, explanation of the conditions described?

This injected and pulpified condition of the muscular tissue may exist in any part, as high up as the point of origin of the muscle.

Even though the soft parts may not present the typical appearance described, and seem healthy, yet their vitality may be so far injured at the time, as to render their reparation impossible; or the gradual supervention of subfascial hemorrhage, higher up in the limb, may, by gradually increasing pressure, destroy the already weakened circulation of the part. Sloughing not unfrequently follows when least expected.

The subject of treatment of those cases requiring amputation, has to a certain extent been foreshadowed in the preceding remarks.

In statistics of amputations performed at St. Francis' Hospital, Jersey City, published in "The American Journal of the Medical Sciences," April, 1881, I use the following language, referring to the damaged condition of the parts above the seat of injury, "a recognition of these facts has led to the practice of giving the seat of injury a 'wide berth,' especially as relates to the lower extremity. "In those cases where the injury extends above the lower third of the leg, the rule is to amputate above the knee, or in other words, put a joint between the seat of injury and the point of amputation, as under these circumstances alone can we be assured of sound tissues at the point of the operation. It has occurred in several cases which have come under my observation where this

rule has not been followed, that the operation although most skillfully performed, has resulted in sloughing of the stump, involving re-amputation, re-section of the bone, or death of the patient.

The sloughing involves oftentimes not only the integuments, but also the connective and muscular tissues.

In some cases it has been observed that the muscles slough to a much greater extent than the skin, giving the stump a cupped appearance, with the bone projecting from the centre; the whole resembling an old fashioned candlestick.

Since the introduction of anæsthetics, shock from operation has been reduced to a minimum, and therefore the removal of a few more inches of the limb, is of very little consequence so far as the safety of the individual is concerned; and the perfection reached in the adaptation of artificial limbs amply compensates for the increased shortening.

All these considerations should outweigh the risks of amputation in the immediate proximity of the injury.

It matters very little as to the method of amputating: each giving practically, equally good results.

The subsequent treatment of the patient, and manner of dressing the stump, is often the determining cause of the favorable or fatal termination of the case.

It has been my practice for many years, after the vessels have been tied, to sponge the surface of the stump with water a little below the boiling point, not only for the purpose of dislodging any coagula that may have formed in the interstices of the tissue, but to stop further oozing. The flaps should not be brought together until every particle of oozing has ceased, as it is a recognized fact that any extravasation in the cavity of the stump allowed to remain, is one of the most potent factors of *sepsis*, which frequently occurs where this precaution is not observed. A drainage tube of sufficient size having been placed in position, the flaps are to be brought together and retained by sutures alone.

A stream of some antiseptic fluid (I have as a rule used

Volkman's solution of Thymol) is run through the tube until every trace of color is lost, and the liquid is absolutely clear.

Over all is applied a wad of oakum which is confined with a roller of sufficient tightness, to counteract any spasmodic action of the muscles and give the limb firm support.

The stump is washed out, through the drainage tube, twice or thrice a day. The tube is allowed to remain until all colored discharge has disappeared. The ends of the tube are left free, in order that the syringing may be done without disturbing the dressing.

The fenestræ in the drainage tube should be large enough to prevent clogging by the discharges, and the tube itself should be occasionally rotated, so as to bring the fenestræ in co-aptation with different parts of the wound.

Reliance should not be wholly placed on the tube, as there may be interstices in the stump, which may serve as receptacles for the accumulation of the discharges. In order to obviate any possibility of such a contingency, it is my practice, after washing out the tube, to insert the nozzle of the syringe into the wound alongside of the tube, and thoroughly wash out the wound externally to the tube.

One great source of ill-success is using too small a tube. It is better to have one too large than one too small.

In cases where the injury is received above the knee, and the part requires immediate amputation, the stump should invariably be left open, and treated after the method recommended by the late Prof. Jas. R. Wood, of New York.

In open stumps there sometimes exists, especially in muscular subjects, a strong tendency to retraction of the flaps.

This is to be counteracted by the application of extension, after Buck's method in cases of fracture of the thigh. The straps are to be applied on the anterior and posterior aspects of the limb, and they are further utilized, as gran-

ulation progresses, by pinning the two together, thereby approximating the flaps. By this method the dressing may be renewed, and the wound thoroughly cleansed, without any inconvenience to the patient.

Injuries of the hand and arm occur most frequently from coupling cars.

These injuries vary in degree, from the crushing of a few phalanges to that of the whole upper extremity.

Owing to the greater reparative powers possessed by this part of the economy, we are justified in operating nearer the seat of injury than in the lower extremity. In injuries to the hand, especially, should conservative surgery be carried to its extreme limit.

Injuries to the dorsum of the hand and fingers, are less serious than those involving the palm or palmar aspect of the fingers.

It is my rule, provided the palmar arches are intact, and even one digital artery remains to a finger, to avoid amputation; allowing those hopelessly damaged to slough, and the line of demarcation to form before removing the part affected.

After removing portions manifestly destroyed, such as lifeless parts of fingers attached solely by tendinous and tegumentary connections (and the same remark applies to the toes and feet), the part is immersed in water as hot as can be borne with comfort, and allowed to remain in the bath about half an hour. It is then wrapped in oakum wrung out of warm water, or a hot flax seed poultice, and the whole enveloped in oil silk.

These baths are repeated at intervals of three hours, until the sloughing ceases, and the line of demarcation is formed. The part is then dressed with Bals. Fir, and any portion of bone remaining uncovered by soft parts is removed and the whole allowed to heal by granulation.

By following this plan of treatment it has been my good fortune to save many a hand and foot which had been condemned as irreparable.

In conclusion I beg leave to offer the reports of a few cases illustrative of the preceding remarks.

Case I.—B. received a c. c. c. fracture of the leg at the junction of the lower and middle third, the result of having been run over by a locomotive and train of cars.

Above the immediate seat of injury, there was not the slightest mark to indicate that there was any damage to the subcutaneous soft parts.

Notwithstanding the opposition of two other surgeons, I amputated at the lower third of the thigh.

On dissecting the amputated part, the gastrocnemii were found lacerated and pulpified at several points, at which were found extensive extravasations of blood. Underlying the whole was found a string of coagula, extending from the seat of injury to the popliteal space. The patient made a rapid recovery.

Case II.—Pat Gilligan, aet 27 years, was admitted to St. Francis' Hospital, Jersey City, Sept. 5th, 1875, on account of a c. c. c. fracture of the right leg, at the lower portion of the lower third, having been run over by a train of cars. Amputation was performed at the junction of the lower and middle thirds. The soft parts at this point were apparently sound.

In a few days sloughing of the stump set in to a greater extent in the subcutaneous tissues than in the skin.

The stump ultimately assumed the cup shaped appearance heretofore described. The patient finally recovered and was discharged from the hospital May 27th, 1876.

Case III.—Reported by Dr. F. D. Gray, interné to "The Jersey City Charity Hospital."

"On the morning of August 2d, 1883, Mark Setor, aet 35, laborer, was admitted to the Charity Hospital, Jersey City, suffering from the effects of a railroad accident which occurred several hours previous.

Examination showed that he had sustained a c. c. fracture of the right tibia and fibula about the middle third, also a crushing injury of the right foot.

"The patient was however suffering severely from shock, and the operation (amputation) was postponed till the next day, hoping that his condition would improve. Under the influence of stimulants and nourishment the patient rallied sufficiently so that the operation was deemed expedient.

The point selected for the operation was about two inches below the knee joint. The external wound being quite extensive and reaching pretty well up toward the knee. It was barely possible to secure sufficient sound tissue to make the flaps, (antero posterior.) In fact the inner border of the anterior flap was made up in part of the edge of the wound. A drainage tube was introduced, the flaps united throughout by sutures, and wrapped in towels wrung out of hot water, then again surrounded by a layer of cotton. The dressing was repeated often enough to keep up the warmth of the stump. The stump washed out three times daily with a two per cent. solution of carbolic acid.

The patient rallied quite satisfactorily from the immediate effects of the operation, and for eight or ten hours did as well as could be expected. After this he began to grow restless and slightly delirious. On the morning of August 4th (day following the operation) the stump presented a swollen and discolored appearance. Its temperature was lowered, and on pressure it gave the crackling of emphysematous tissue. In short, it had all the appearance of beginning decomposition.

Stimulants and nourishment, together with anodynes, were freely administered, but with no effect, as the patient grew rapidly worse, delirium and restlessness increasing, while at the same time he became exceedingly weak. Death occured about two o'clock on the morning of Aug. 5th—about thirty-six hours after the operation.

Before death the cellular tissue of the stump had become emphysematous from generation of gases up to the middle of the thigh.

I am indebted to Dr. John D. McGill, surgeon to St. Francis' Hospital, for the reports of the three following cases:

Case I.—Patrick Nicholson, aged 19, brakeman by occupation, was admitted to St. Francis' Hospital, Nov. 9th, 1881, having sustained a c. c. fracture of the bones of the foot.

The soft parts about the seat of injury, and extending as far as the malleoli, were more or less contused and lacerated. Above the malleoli the tissues appeared to have escaped serious injury, and were apparently healthy.

Amputation was performed at the lower third of the leg, with long anterior and short posterior flaps. The open method of treatment was adopted. The patient rallied well from the operation.

Forty-eight hours after the operation the anterior flap presented a bluish yellow tinge at its lower border, and some ecchymosis was observed on the leg above the stump. Twenty-four hours later the stump presented a swollen, unhealthy appearance. A well defined slough extended about an inch and a-half from the lower border of the anterior flap. A solution of permanganate of potash was applied locally, quinine and opium internally; quinia gr. v. every three hours.

Poultices were subsequently applied to the stump and within eight days about one-half of the anterior flap had sloughed. Two abscesses were opened in the leg above the stump, and several troublesome sinuses slit up.

After this the patient did well, and was discharged cured January 28th, 1882.

In this case although the tissues at the site of operation were apparently healthy, at the time of amputation, subsequent events proved that the limit of injury to the soft parts was considerably higher in the leg.

Case II.—William Size, aet 27 years, railroad employee, July 20th, 1882, sustained a compound fracture below the knee joint.

From the seat of injury to the knee joint, the integument was intact, but the underlying tissues crepitated upon digital pressure. Amputation being decided upon, in view of the doubtful condition of the tissues below the knee, it was determined to operate at the lower third of the thigh.

An examination of the amputated leg disclosed the following:

Seat of injury about the middle of the leg; c. c. fracture caused by the wheel of a rail road car. Skin above the injury intact, but somewhat contused in places.

Muscles were of a bluish red color. Small clots of blood were entangled in the meshes of the muscular fibres which had a frayed look. That the nerves, arteries and veins, had shared injury with the muscles, was plainly evident. This condition of soft tissues extended from the point of direct injury (some six inches below the joint) almost to the knee.

In this case it was apparent, that had the operation been performed below the knee, owing to the fact that the soft tissues were injured beyond reparation, a disastrous result would have been certain.

As it was, the patient made a somewhat tedious but very satisfactory recovery, and was discharged cured September 8th, 1882.

Case III.—Timothy Daly, aet 20 years, was admitted to St. Francis' Hospital November 3d, 1882, having sustained a c. c. fracture of the leg two or three inches above the ankle. The patient was employed as a brakeman on a coal car, had missed his footing, and fallen between the cars. Before he could be extricated two or three cars had passed over his leg, completely severing the foot.

When admitted Daly was suffering severely from shock; skin pale, cold and clammy; pulse feeble and rapid; lips bluish in color. Owing to the mangled and

lacerated condition of the blood vessels at the site of injury, there was but a small loss of blood. The condition of the patient was such that all operative interference was negatived until reaction should take place. Under the use of stimulants, with artificial heat applied to the extremities, the patient slowly reacted so as to be in condition to permit amputation in about 12 hours after the injury was received. In this case as in case II, owing to the nature of the accident and irreparable injury to subcutaneous tissues and blood vessels, it was deemed expedient to operate above the knee. An examination of the amputated leg revealed about the same condition of the muscles and blood-vessels that was noticed in case II. The degree of injuries to the tissues being perhaps a little greater. Without the occurrence of other incidents worthy of note, Daly made a satisfactory recovery and was discharged cured January 11th, 1883.

Many more cases might be quoted did time and space permit.

That the method of treatment advocated, has not been barren of results, I report that since August 12th, 1879, during my various periods of service at St. Francis Hospital I have performed 21 major amputations, without a death. All with the exception of two were for c. c. fractures the results of rail road accidents. Of these, 15 were primary and 6 secondary, which are classified as follows:

Thigh, primary, 6. Secondary, 4	10
Leg, primary	3
Hip joint, secondary	1
Shoulder joint, primary	1
Arm, primary 2. Secondary, 1	3
Fore arm, primary	3
Total	21

In the Jersey City Charity Hospital during the same period, I performed 7 major amputations with one death.

All these cases were for c. c. fractures the result of rail road injuries, viz.:

Thigh, primary	5
Leg, primary	1
Fore arm	1
Total	7

The fatal result in one case was due to secondary hemorrhage occurring on the fourth day after the operation. The patient was a broken-down tramp, and the hemorrhage due to sloughing of the stump, opening the femoral artery above the ligature. In private practice I report three cases, all successful, viz:

Thigh, secondary	1
Leg, secondary	1
Arm, primary	1
Total	3

This gives a total of 31 cases, with 1 death.

Finally, the treatment may be epitomized in one sentence, viz:

Amputate through sound tissues, and keep the stump clean.